NATIONAL AND INTERNATIONAL COOPERATION IN SCIENTIFIC EXPERIMENTS ON FUTURE EARTH-ORBITING SPACECRAFT

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Introduction

The National Aeronautics and Space Act of 1958 contains a remarkably comprehensive statement of the objectives of U.S. activities in space exploration, making it crystal clear that they extend far beyond the scientific objectives which are discussed in this paper. Congress first declares that it is the policy of the United States that space activities be devoted to peaceful purposes for the benefit of all mankind. The Act then lists eight objectives which may be paraphrased under five topics, as follows:

1. The expansion of human knowledge of phenomena in the atmosphere in space. This is the scientific objective which includes studies of the region near the earth, interplanetary space, and the celestial bodies;

2. The advancement of the technology of aeronautics and space flight;

3. The application of space science and technology to the conduct and utilization of space flight for the benefit of man;

4. The most effective utilization of the scientific and engineering resources of the United States; and

5. Cooperation by the United States with other nations and groups of nations in space activities.

Each objective supports the others. We are here concerned with the scientific aspects. Our current space activities not only represent the application of scientific results already available and stimulate the advance of almost all fields of science carried out in laboratories on the ground, but open up completely new breathtaking vistas through the new opportunities for making scientific measurements in the high atmosphere and outer space. We have launched many small earth satellites to make measurements within the ionosphere and of the ionosphere from above, to measure electric and magnetic fields and charged particles, the density of the air near the earth and the flux of micrometeoroids. Within the past year we launched the second Orbiting Solar Observatory for studies of the sun and the first Orbiting Geophysical Observatory for studying the earth. An unmanned Orbiting Astronomical Observatory for use in a satellite in space is nearing completion.

As Dr. Homer Newell, NASA's Associate Administrator for Space Science and Applications, has pointed out:

-- "The United States has acquired and published more scientific data on space than any other nation.

-- We have made use of our space knowledge and our technology for peaceful applications and the general benefit of mankind to a degree unsurpassed by any other nation.

-- We have provided for international participation in our projects in a variety of ways that have made us the world leader in this area.

-- We have provided more avenues for participation in the space program by interested citizens of our own country than any other nation has provided for its citizens.

[redacted]

Never before in man's history has an exploration program yielded so much new knowledge and so many benefits for so many people in so short a time--and never before have so many people been able to take part so soon after it started." [1]

These accomplishments have been achieved only through the cooperation of many experimenters in universities, industries, and government laboratories in the United States and abroad.

National Cooperation in Earth-Orbital Programs

Extension of our experience with the unmanned programs to the manned earth-orbital programs is now under way. The Office of Space Sciences and Applications of NASA has issued an announcement, "Opportunities for Participation in Space Flight Investigations," January 1965, inviting proposals from the scientific community to obtain the best possible selection of flight investigations for both the manned and unmanned programs.[2] NASA's sustaining university program was inaugurated in 1962 to increase university participation in aeronautical and space sciences and engineering, thereby strengthening the Nation's rapidly expanding space program. The program is designed to increase the future supply of engineers and scientists trained in space-related fields; assist universities to provide additional research facilities for conducting space research; and encourage new, creative approaches to research problems and develop new research capabilities.[3]

The possible manned scientific missions are shown in Figure 2, but only Gemini and Apollo are firmly approved and funded programs. Studies are under way of possible experiments for future possible missions, and suggestions for experiments have been received from many institutions and from many scientific disciplines. Members of teams planning experiments for Gemini, Apollo, and advanced manned orbiting programs come from all over the country and from universities, from industry, from government, and from nonprofit organizations. Because of the potential for a large number of experiments of diverse types, the aid of scientists in many parts of the Government has been sought. The agencies listed in Figure 3 are already taking an active role, and it is expected that they will participate to a larger degree than ever before.

The breadth of science involved in the Apollo and possible future orbital programs is also larger than ever before. The scientific experiments include not only those of interest to the basic, classical scientists, such as physicists and astronomers, but also newer disciplines. The future experiments are expected to be of value to meteorologists and pollution-control researchers (atmospheric science and technology); to geologists, hydrologists, and oceanographers, as well as to geographers and agricultural researchers (earth sciences and resources). In a later paper on the program Dr. Peter C. Badgley will describe experiments of these types including integrated sets of instruments having sensors "looking" in various parts of the spectrum simultaneously.

The early manned science programs depend for their success on astronauts trained in science. As you know, the group of astronauts has been expanded and includes not only members of the three military services but also civilians. Some science training is being given to all of them. This year an invitation was extended to scientists to become astronauts. The National Academy of Sciences undertook to define the scientific qualifications, and NASA combined these with the physical qualifications to define the type of individual desired. By the end of December, NASA had received more than nine hundred applications for the scientist-astronaut positions. Candidates are being screened and tested, and it is planned to select from ten to twenty to start a year of flight training this summer. In the Mercury program, the astronauts demonstrated man's ability as a sensor, as a manipulator, and to some extent as an evaluator. Early Gemini and Apollo flights will further examine these capabilities so that, in the future, man's full potential can be exploited. Space-borne scientists will become members of the team as the exploration of space proceeds.

Ways to Participate in Manned Space Science Programs

In the previous sections I have indicated some of the types of people who will participate in the manned space science programs. I would now like to point out some of the ways to participate. Of course, the actual flight experiments are the most glamorous. However, there are other ways which have considerable scientific importance.

The area of feasibility studies is proving more and more important. These involve not only analyses of phenomena, parameters, and sensitivities, but also instrument conception, design, construction, and test. In particular, some of the sensors planned for use for lunar and planetary geological examination from orbit will be tested first in aircraft and then in earth-orbital spacecraft over known sites for purposes of calibration.

Post-flight analysis of large amounts of data is another area for participation. In some cases where experimenters do not wish to become active in the actual flight program, they may become part of the overall experiment team and participate in the data reduction and analysis. This is particularly true for the lunar surface experiments where an important part of the scientific program will be the post-flight examination of returned samples.

In regard to the flight experimentation, as the size and the number of spacecraft increase, there will be more opportunities for participation. There were only a few scientific experiments aboard the manned Mercury flights, while Gemini will carry twelve exclusively scientific experiments (out of a total of about fifty), and the early Apollo earth-orbit tests will have on the order of twenty. These three vehicles permit tests of tens of pounds of experiments on a "piggy-back" basis. However, as shown in Figure 4, some of the future manned space programs will probably involve large manned spacecraft devoted exclusively to scientific experimentation.

Preliminary studies indicate that we are near a cross-over point. In the cases of Mercury, Gemini, and the initial Apollo earth-orbital tests, weight, volume, and power were prime limitations. Hence the experiments were collections of almost independent investigations not requiring any appreciable electrical power. For the large manned orbiting laboratories of the future, weight, volume, and power, while still important, become less of a limiting factor in the selection of experiments. Rather, the limitation seems to be the ingenuity of the experimenter and the astronaut time available to conduct the investigations.

We foresee a change from missions composed principally of small, independent experiments to those based on larger, more complicated, multi-purpose instruments. Instead of the small, hand-held 35- and 70-mm. cameras as in Mercury and Gemini, future missions may carry a battery of cameras for visual panoramic and mapping purposes as well as multi-spectral photography. Instead of individually packaged laboratory-type experiments, multi-purpose equipment and life-support systems may provide greater experimental efficiency. Hence, more and more useful data will be available for experimenters.

International Cooperation

The opportunities for experimentation which I have discussed here are also made available to foreign researchers within the framework of NASA's international cooperative program. This program is conceived as one resting on mutual interest. On the one hand, NASA stands to gain from foreign experiments of merit contributed to its programs. On the other hand, foreign experimenters gain opportunities to perform experiments in spacecraft not otherwise available to them. Each side carries out its responsibilities with its own resources and without exchange of funds. Thus, foreign experiments which are selected for flight must be brought to the point of flight readiness at the cost of their foreign sponsors. NASA, on the other hand, integrates the experiment in the spacecraft and provides the launching at its cost.

The initial association of NASA with foreign experimenters in such a program is achieved in the following way: When specific flight programs are approved, NASA invites proposals from experimenters and extends these invitations also to foreign experimenters and space authorities. Foreign proposals may then be submitted directly to NASA headquarters or through the foreign national space agency. They are then reviewed in precisely the same manner as domestic proposals are considered and in competition with them and other foreign proposals. Selection is on the merits.

With opportunities, of course, go limitations of one kind or another. And these should be recognized by all concerned. The foreign experimenter will have to address himself to new constraints of weight, volume, and power. Future Apollo programs will be less restrictive in these respects than past programs, but they will nevertheless impose limitations generally not met in earth-bound laboratories. The experiments will have to fit into a total environment represented by the spacecraft itself and a complex of companion experiments. There will be stringent requirements to assure compatibility, not only in the basic engineering of the experiment but also in electric and magnetic terms. The ultimate test of flight readiness will require the experimenter to meet standards of mechanical integrity well beyond those normally encountered. These in turn may require the use of materials not normally worked with and access to environmental test facilities for thermal, vacuum, and vibration tests. All in all, the high order of technical standards and the sharp constraints which apply will require a continuing and close association between experimenters and project engineering personnel throughout the period of preparation.

Security questions have not significantly interposed themselves in our cooperative programs since the NASA programs themselves are so largely open. Nevertheless, there is a distinction between science and technology. Technology often brings with it proprietary and in some cases classified elements. It is perhaps well to recognize that some limitations with regard to access may be encountered from time to time. It is unlikely, however, that these would be disabling or seriously limiting to the scientific experimenter.

The general relationships and procedures described here as applicable to foreign experimenters have been working with outstanding success in the case of our observatory satellites. More than a dozen foreign experiments have been selected for flight on these satellites.

Conclusion

It may be concluded that, in accordance with NASA objectives and past policy, continued cooperation with both national and international scientists will be encouraged in the manned space science program. The future manned spacecraft will offer a much wider scope of opportunity for participation. There will be many avenues open to many types of investigators. Emphasis will continue to be placed on good experiments which will be carefully screened as to scientific value, as to engineering and operational compatibility, and as to utilization of potential scientists-astronauts.

References

1) Dr. Homer E. Newell, Associate Administrator for Space Science and Applications, NASA, "Statement before the Sub-Committee on Space Science and Applications, Committee on Science and Astronautics, House of Representatives," February 1965, page 1.

2) NASA, Office of Space Science and Applications, "Opportunities for Participation in Space Flight Investigations," January 1965.

3) NASA, "Eleventh Semiannual Report to Congress, January 1 - June 30, 1964, Grants and Research Contracts Activities," page 149 ff.

FIGURE 1

MAJOR NASA OBJECTIVES

1. THE EXPANSION OF HUMAN KNOWLEDGE OF PHENOMENA IN THE ATMOSPHERE IN SPACE;

2. THE ADVANCEMENT OF THE TECHNOLOGY OF AERONAUTICS AND SPACE FLIGHT;

3. THE APPLICATION OF SPACE SCIENCE AND TECHNOLOGY TO THE CONDUCT AND UTILIZATION OF SPACE FLIGHT FOR THE BENEFIT OF MAN;

4. THE MOST EFFECTIVE UTILIZATION OF THE SCIENTIFIC AND ENGINEERING RESOURCES OF THE UNITED STATES; AND

5. COOPERATION BY THE UNITED STATES WITH OTHER NATIONS AND GROUPS OF NATIONS IN SPACE ACTIVITIES.

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FIGURE 2

POSSIBLE MANNED SCIENTIFIC MISSIONS

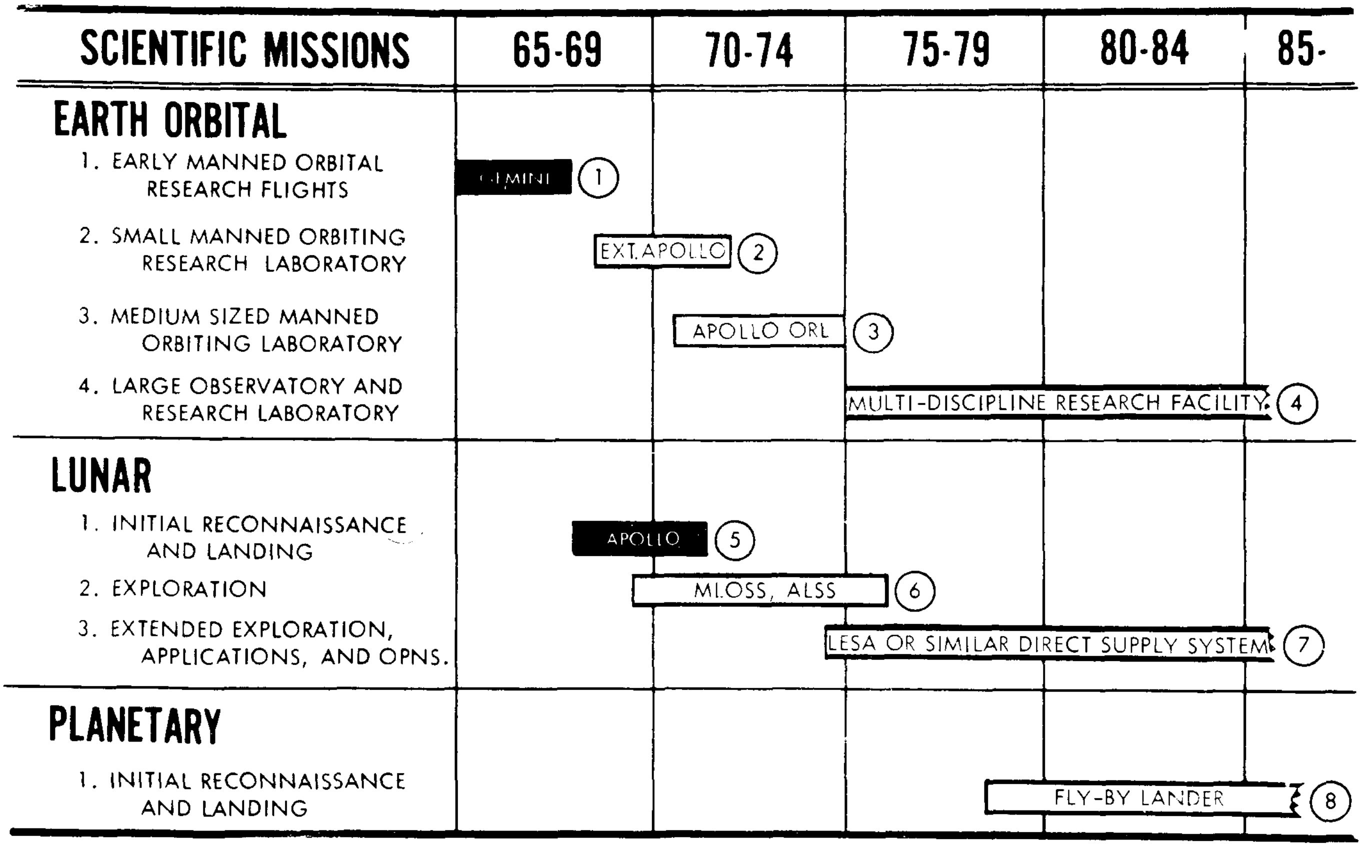

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FIGURE 3

GOVERNMENT AGENCIES HAVING REPRESENTATIVES PARTICIPATING IN AES SCIENCE/APPLICATIONS PLANNING

DEPARTMENT OF AGRICULTURE

DEPARTMENT OF COMMERCE - WEATHER BUREAU
COAST AND GEODETIC SURVEY

DEPARTMENT OF DEFENSE

DEPARTMENT OF ARMY (MAPPING RESEARCH AGENCY)

DEPARTMENT OF NAVY (OFFICE OF NAVAL RESEARCH)
(NAVAL OCEANOGRAPHIC OFFICE)

DEPARTMENT OF AIR FORCE (CAMBRIDGE RESEARCH LABORATORY)

DEPARTMENT OF INTERIOR - U.S. GEOLOGICAL SURVEY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(HEADQUARTERS, AMES, GODDARD, JET PROPULSION LABORATORY, MANNED SPACECRAFT CENTER)

NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL

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FIGURE 4

AS THE SIZE AND NUMBER OF SPACECRAFT INCREASE, THE OPPORTUNITIES FOR PARTICIPATION EXPAND

MANNED SPACE SCIENCE PROGRAM	NUMBER OF EXPERIMENTS	WEIGHT OF EXPERIMENTS	NUMBER OF MEN	OPPORTUNITIES FOR PARTICIPATION
MERCURY	A FEW	FEW POUNDS	1	NONE - COMPLETED
GEMINI	12 SCIENTIFIC	TENS OF POUNDS	2	NONE - ALL SELECTED
APOLLO (PIGGY-BACK IN EARTH ORBIT)	ABOUT 20 SCIENTIFIC	TENS OF POUNDS	3	DEADLINE: JAN. 1966
APOLLO EXTENDED	MANY	OVER A THOUSAND POUNDS	2-3	YES - PLANNING STAGE
LARGE LABORATORIES AND OBSERVATORIES	VERY MANY	MANY THOUSANDS OF POUNDS	6-12 OR MORE	YES - CONCEPTUAL STUDY STAGE

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